



Introduction to Nonlinear Optics and its Applications

Physics

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Department: Physics

Course Intro: : Nonlinear Optics is one of the important subdisciplines of Modern Optics. It mainly deals with the light-matter interaction when the material response is nonlinear. In the prescribed course we study the basic nonlinear optical effects (like higher harmonic generation, optical Kerr effect, self-phase modulation etc) that take place when the material is illuminated by a strong light (preferably Laser). The course offers the subject matter by giving a rigorous theoretical background and framework for a nonlinear effect, followed by details of how such an effect is implemented in real applications. The course is prepared for the senior graduate students having a prior idea of electromagnetic theory. The course is also useful to the junior PhD students whose research interest is related to Photonics.

Pre Requisites: : Knowledge of Basic Optics & Electromagnetic Theory

Core/Elective: : Elective

UG/PG: : Both

Industry Support : NA

Reference : Nonlinear Optics by R. W. Boyd 2. Introduction to nonlinear optics by G. New 3. Fundamentals of nonlinear optics (2 nd Ed.) by P.E. Powers, J.W. Haus 4. Nonlinear Optics: Principles and Applications by C. Li

About Instructor: I completed my PhD from CGCRI (a CSIR Lab) in 2009 and carried out my post-doctoral research from Hokkaido University, Japan and Max Planck Institute, Germany during 2009-2013. In 2013, I joined in the Physics Department of IIT-KGP as an assistant professor. My research interest includes nonlinear photonics and optical soliton dynamics.



COURSE PLAN

SL.NO	Week	Module Name
1	1	Introduction & Linear Optics: Maxwells Equation (in free space and medium), Wave equation (Homogeneous and Isotropic medium), Plane wave solution, Poynting Theorem, Intensity and Amplitude relation, Linear Polarization, Classical 1D anharmonic oscillator, Refractive Index, Dispersion (Damped Harmonic Oscillator Model, Sellmeier Equation).
2	2	Polarization Tensor, Susceptibility Tensor, Wave motion in Crystal, E-Ray & O Ray, Walk Off.
3	3	Nonlinear Optics: Nonlinear Susceptibility, 2 nd order nonlinear effect- Optical Rectification, 2 nd harmonic generation, Nonlinear Maxwell's equation, Concept of phase matching.
4	4	Birefringence Phase Matching (BPM), Kleinman's symmetry, Index contraction, d-matrix, Quasi Phase Matching (QPM)
5	5	Parametric Processes, Three wave interaction, Difference frequency generation, Manley-Rowe Relation
6	6	Phase sensitive and insensitive amplification, Sum frequency generation,
7	7	Optical Parametric Oscillator (OPO) (i) Singly Resonant Oscillator (SRO), (ii) Doubly Resonant Oscillator.
8	8	3 rd order nonlinear effect, Optical Kerr effect, Self Phase Modulation (SPM).
9	9	3 rd harmonic generation, Two wave interaction, Cross Phase Modulation (XPM).
10	10	Nonlinear absorption Two Photon Absorption (TPA), Four Wave mixing, Cross Talk, Optical Phase Conjugation
11	11	Stimulated Raman Scattering, Classical Picture of SRS, Raman Gain, Applications.
12	12	Nonlinear Schrödinger Equation, Optical soliton, Applications